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DEVICE FOR MEASURING LIGHT-ACTIVATED FLUORESCENCE AND ITS USE

The invention relates to a device for measuring fluorescence excited by light at at least one layer containing a fluorescing material, and to the use thereof for measuring fluid materials which effect fluorescence quenching in at least one of the fluorescing layers.

Measuring methods and measuring devices customarily used to date have the disadvantage that the ratio of fluorescent light to the light required to excite the fluorescence is very low, with the result that a separation is required and, consequently, a miniaturization, which is necessary for many applications, has so far been ruled out.

Further known solutions do not achieve satisfactory separation between the exciting light and the fluorescent light.

To counter this, use has so far been made of an expensive, complicated optical design which requires many optical elements, which are also cost intensive, the result being, in particular, the appearance of problems with the miniaturization and process integration.

The known solutions also have the disadvantage that the detection of the measuring signal has proceeded relatively slowly and that furthermore, errors have occurred due to coupling drift (temperature fluctuation, mismatching, or due to modem coupling), and could be taken into account only with difficulty.

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DD 106 086 describes a measuring probe in which fluorescence is excited in a layer, the exciting light being directed onto the layer by a single optical fibre which surrounds, in the shape of a ring, at least one further optical fibre for fluorescent light. The fluorescent light can be measured with a detector, and the measured value thereof can be used as a measure of the content or the concentration of a material, as a

consequence of fluorescence quenching. Use is made for a reference measurement of a second optical fibre which directs fluorescent light of a layer region, which is screened from the measurement medium, onto a second detector.

However, it is not possible with this solution to ensure a concrete and accurate local assignment of the detectable fluorescence intensity over the excited layer surface, something which is, however, also necessary for accurate measurements because of an imprecisely defined local excitation or a non-defined, inhomogeneous arrangement of the fluorescing material in the layer. Moreover, an absolute optical separation is necessary for a simultaneous reference measurement or further measurements for other materials.

It is therefore the object of the invention to propose a device which can be of miniaturized construction and therefore be adapted flexibly to different applications and achieves a satisfactory measuring accuracy.

According to the invention, this object is achieved by means of the features of Patent Claim 1. Advantageous embodiments and developments of the invention follow in the case of the use of the features named in the dependent claims.

The device according to the invention for measuring fluorescence excited by light at at least one layer containing a fluorescing material essentially comprises a measuring head in which at least one light source which emits light of wavelength(s) exciting fluorescence(s) in the layer or layers, and at least one detector which measures the intensity of the fluorescent light, are held. The light directed onto the layer(s) in order to excite the fluorescence is directed onto the fluorescing layer via at least one optical conductor. In this case, the same optical conductor can also direct the fluorescent light onto the detector. A plurality of fluorescing layers can be arranged next to one another in a fashion separated

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from one another locally or, if appropriate, partially overlapping, and be irradiated in each case with exciting light.

It is important for the end faces of the optical conductors of the fluorescent light to be arranged and/or aligned taking account of the numerical apertures of all the optical conductors, in order to achieve an accurate local assignment of the measured values. A further possibility for achieving this aim consists in aligning these optical conductors with reference to one or more layer(s) containing fluorescing material(s).

For the measurement, the fluorescing layer(s) is/are arranged on the end or ends of the optical conductors or on a suitable support or a body, or make contact therewith.

Optical fibres are preferably used as the optical conductors.

There is thus, in principle, the possibility of arranging a plurality of different fluorescing layers, and using them with one or more different light sources which in each case emit light with wavelengths which excite fluorescence(s). It is thereby possible with the aid of only one measurement to detect a plurality of different fluid materials which effect fluorescence quenching in the different layers.

However, the invention can also be developed for the use of a plurality of optical fibres which direct different types of light to different detectors arranged separately from one another.

Thus, for example, the light of a light source can be directed onto a fluorescing layer, from there the fluorescent light can be directed by a second optical fibre onto a detector arranged in the measuring head, and, for the purpose of obtaining a reference signal, exciting light reflected in the layer can be directed onto a second detector by a third optical fibre. The third, or an additional, optical fibre can also be used for a second fluorescent light.

In this case, the fluorescing layer or a plurality of fluorescing layers which are preferably applied to a substrate serving as support can simply be plugged onto the measuring head using a cap or an exchangeable support, thus rendering a simple exchange possible. In this case, it is particularly advantageous when a coupling medium is present between the substrate, to which the fluorescing layer(s) is/are applied, and the ends of the optical fibres, in order to reduce light losses.

It is favourable for various applications when at least a part of the measuring head, and in this case at least the part which holds the optical fibres, which is directed in the direction of the fluorescing layer(s), is of flexible construction, or the upper part of the measuring head is at least partially bent.

In order to improve the optical properties of the device according to the invention, it is advantageous for a filter and/or a launching optical system to be arranged between the light source or sources and the respectively assigned optical fibres, in order, on the one hand, to avoid light losses and, on the other hand, to delimit the wavelength region of the light which is directed onto the respective fluorescing layer, so that the measuring errors can be further reduced. It is particularly favourable that the filters can be exchanged for others which are suitable for other wavelengths, that is to say other fluorescing materials, and consequently also other materials to be detected.

A corresponding arrangement of coupling-out optical systems and/or filters upstream of the various detectors acts in the same way.

In the device according to the invention, however, it is also possible to make use of a bundle of a plurality of optical fibres, it being possible to arrange the individual optical fibres in the bundle differently in order to be able to detect optimum measuring signals of fluorescent light, and reflected

light of the light source(s) moreover measuring errors can be minimized. The arrangement of the individual optical fibres in the bundle can be performed in this case in the shape of a ring, in one variant, and in the shape of a star, in a second variant.

In the case of an arrangement in the shape of a ring, it is possible to arrange next to one another in an alternating interchanging fashion in an outer ring optical fibres which, on the one hand, direct exciting light onto the fluorescing layer and direct light reflected there as reference signal onto a detector. It is then possible to arrange in a ring internal thereto optical fibres which direct fluorescent light onto at least one detector in the measuring head. An additional optical fibre which likewise directs exciting light onto the fluorescing layer can then be arranged at the centre of the ring.

In an arrangement of the individual optical fibres in the shape of a star, it is favourable to arrange at the centre of the star an optical fibre through which exciting light is directed onto the fluorescing layer, and to arrange next to one another in the shape of a star in an alternating interchange, optical fibres with which reference light and fluorescent light are directed onto detectors.

The arrangement of the respective optical fibres for the various types of light can, however, also be selected taking account of the arrangement of different fluorescing layers, it being possible, for example, to select an arrangement of the optical fibres in the shape of a circular arc when the fluorescing layers are preferably constructed as circular arcs and the local assignment is taken into account.

In another embodiment of the device according to the invention, the individual optical fibres are not, however, arranged in parallel but, at least in their end regions, that is to say in the direction of the fluorescing layer(s), are inclined at specific angles to one another, so that, for example,

fluorescence-exciting light is directed at a specific angle, which is not equal to 90°, onto the fluorescing layer, and there is aligned at a second correspondingly aligned angle at least one optical fibre by which the reflected reference light can enter and be directed onto a detector. A third optical fibre can then preferably be arranged orthogonally relative to the fluorescing layer through which the fluorescent light reaches the corresponding detector.

In all these cases, however, it is favourable to arrange and/or align the optical fibres such that for the purpose of launching and coupling out exciting and fluorescent light their end faces permit a local assignment of the measured fluorescent light, taking account of their numerical apertures.

It is favourable for specific applications of the device according to the invention when, at least in the upper measuring head region, a heater is present which can prevent condensation of, for example, water on the fluorescing layer(s). Moreover, it is favourable to use at least one temperature sensor and a corresponding controller or regulator to manipulate the heater in accordance with the ambient conditions, that is to say the ambient temperature and the atmospheric humidity, and thereby to be able to set different prescribable temperatures in the region of the fluorescing layer(s) and/or in the upper measuring head region. The heater can in this case be arranged in the upper measuring head region, but it is also possible to arrange appropriate heating elements in the immediate vicinity of the fluorescing layer(s). One possibility for this is to fit the heater on the substrate to which the fluorescing layer(s) is/are applied.

The device according to the invention can further be improved when the lower region of the measuring head is constructed in a thermally insulated fashion with respect to the upper heated measuring head region.

It can be favourable for various applications to construct the upper measuring head region not only in a flexible fashion but also in a tapering fashion, solely or in conjunction with a flexible design, it being possible to taper virtually to the diameter of the optical fibres.

Depending on the actual design of a measuring device according to the invention, it is then possible to detect at least one fluid material which effects a specific quantifiable measure of fluorescence quenching in the fluorescing layer. It is possible in this case to detect different materials with different fluorescing layers which are arranged next to one another. However, it is also possible in principle to detect a plurality of materials by directing light of different wavelengths onto only one fluorescing layer and carrying out the detection in terms of wavelength resolution.

Despite an at least partially integrated electronic evaluation system, the device according to the invention must be of small and flexible construction so that the most varied applications are possible. In particular, the slim and, if appropriate, flexible construction of the upper measuring head region has the positive effect that alignment relative to the measuring location or to the fluorescing layer(s) is possible in a simple way.

A further advantage consists in that the optical fibres can be used without rigid connections, such as optical connectors, with the result that an exchange is possible although the optical fibres are held fixed and therefore can no longer be moved, it thereby being possible to avoid modal noise.

If a plurality of optical fibres are used as a bundle, the most varied arrangements at the end of the measuring head in the direction of the fluorescing layer(s) can ensure optimum measuring conditions and reduce the component of scattered light as well as greatly minimize crosstalking of exciting light, and it

is also possible in this case to detect a reference signal.

The spatial separation and additional thermal insulation of the upper measuring head region can optimize the temperature control in the region of the fluorescing layer(s) with reference to energy consumption, and unnecessary heating of the lower region of the measuring head is prevented.

Further advantages of the invention are the better and more effective illumination of the fluorescing layer(s), and less influence from extraneous and scattered light.

The invention can take account of a plurality of material concentrations by means of different fluorescent dyes and/or reference signals. It is possible for such layers to be selectively excited and correspondingly detected.

The temperature control or heating can be carried out only in the immediate vicinity of the layers.

There is no need for any external optical connectors which could lead to coupling problems.

Miniaturization, a lower mass and, in addition, flexible access to the measuring medium are possible by optical separation of measuring tip and the detection and evaluation of measured values.

The device according to the invention is not only capable of flexible construction, but is also cost-effective to produce and operate, since some parts can also be replaced cost-effectively by being exchanged.

The invention is to be described in more detail below using exemplary embodiments.

In the drawing:

Figure 1 shows the diagrammatic design of a first example of a device according to the invention;

Figures 2, 2a, 2b show various arrangements of optical fibre bundles on the upper measuring head;

Figures 3, 3a, 3b show three examples of a measuring head according to the invention, in two views in each case;

Figure 4 shows a first example of a support which can be mounted on a measuring head, in two views;

Figure 5 shows a second example of a support which can be mounted on a measuring head, in two views;

Figure 6 shows a third example of a support which can be mounted on a measuring head, in two views;

Figure 7 shows a fourth example of a support which can be mounted on a measuring head, in two views;

Figure 8 shows a fifth example of a support which can be mounted on a measuring head, in two views;

Figure 9 shows a support with a symmetrically constructed planar optical conductor;

Figure 10 shows two symmetrically arranged supports;

Figure 11 shows examples for launching light into and coupling it out of end faces of supports which can be mounted on a measuring head;

Figure 12 shows a sixth example of a support which can be mounted on a measuring head, in two views;

Figure 13 shows a seventh example of a support which can be mounted on a measuring head, in two views;

Figure 14 shows an eighth example of a support which can be mounted on a measuring head, in two views;

Figure 15 shows a ninth example of a support which can be mounted on a measuring head, in two views;

Figure 16 shows a body which can be mounted on a measuring head;

Figure 17 shows a body which can be mounted on a measuring head;

Figure 18 shows a body which can be mounted on a measuring head;

Figure 19 shows a first holder for fluorescent layers, in three views;

Figure 20 shows a second holder for fluorescent layers in three views;

Figure 21 shows a measuring head for measuring with wavelength resolution, and

Figure 22 shows a further measuring head in two views.

The diagrammatic design of a first exemplary embodiment of a device according to the invention is represented in Figure 1.

In this case, there is held in the closed measuring head 1 at least one light source 2 from which exciting light is directed onto a fluorescing layer 11 via a filter 6, which is preferably also an exchangeable bandpass filter, by the optical fibre 3, which is guided through the upper measuring head region 17. Fluorescent light from the fluorescing layer 11 passes through a second optical fibre 15 via an edge filter 6, possibly likewise exchangeable, onto a detector 4 with which the intensity of the fluorescent light can be measured, and the detector 4 is connected to an electronic evaluation system 9.

Reflected light then passes as reference signal through a third optical fibre 16, likewise via a filter 8, which can, again, be exchangeable, onto a second detector 5, which is connected to a second electronic system 10.

In this case, the exchange of the filters 6, 8 is advantageously to be possible from outside via openings with a lock.

A heater 12 which is mounted in a metal tip 14 in order to improve the thermal conduction is then provided in the uppermost region of the upper measuring head region 17. Likewise held in the metal tip for the purpose of controlling or regulating the heater 12 is a temperature sensor 13 whose measuring signal is led to an electronic control system which then influences the heat output.

Two lines at the lower part of the measuring head 1 indicate connections to an electronic evaluation system which can further process the preprocessed signals from the electronic systems 9 and 10, and display and output them.

Of course, the number of the light sources 2 of the detectors 4 and 5 can be appropriately increased.

Different variants for possible arrangements of different optical fibres are then represented in Figures 2, 2a and 2b. Here, the upper representation in Figure 2 shows a bundle of different optical fibres, the filled-in optical fibres 20 directing light of the light source 2 onto the fluorescing layer. The hatched optical fibres 21 direct the light reflected at the layer as reference signal onto the detector 5, and the optical fibres 22, 23 direct fluorescent light from the fluorescing layer or layers onto one or more detector(s) 4.

Various arrangements of three optical fibres are represented in the lower left-hand and middle representations, the respective function corresponding to that already explained in the case of the above representation. Reproduced in the lower right-hand representation is an arrangement in the shape of a star of optical fibres in which a central optical fibre 20 for exciting light and, in alternating exchange around the middle optical fibre 20, optical fibres 21 and 22 are arranged, it being possible for the number of the optical fibres 21 and 22 arranged in the shape of a star to be increased at will.

In the lower representations of Figure 2, furthermore, the guidance of the different optical fibres 20, 21 and 22 in the upper measuring head region 17 is represented in preferred form. In this case, different optical fibres, arranged in the outer region, in particular, are constructed in an angled fashion so that it is possible to achieve an improved illumination of the fluorescing layer, and a reduction in the influence of extraneous light and scattered light.

The examples represented in Figure 2 are not only, however, limited to a design of a measuring head, according to the invention, in which only one fluorescing layer is used. A plurality of different fluorescing layers are used on the measuring head according to the invention, a local assignment of the different optical fibres required for the measurement can be performed in a simple way, with the result that optimum conditions can be obtained in each case for the various fluorescence and reference signals.

In each case, the optical fibres 22 can, however, be arranged and/or aligned such that, even taking account of their own numerical apertures and those of the optical fibres 20 for exciting light, locally defined regions can be detected in the layer or layers.

A second example of a measuring head 1 according to the invention is represented in Figure 3, in two views, from which it emerges that such a measuring head has a smaller width in relation to its length, and therefore, in particular, offers more favourable preconditions for measurement in flowing media than is the case with, for example, circular or square shapes, since the flow conditions, and consequently also the measurement result, can be negatively influenced by, for example, turbulence which is produced, higher flow rates or pressure rises.

Exchangeable supports, of which a few examples are represented in Figures 4 to 15 still to be described below, can then be mounted on such a measuring head 1.

As is also to be seen in Figure 3, optical fibres 3, 15, 16 can be arranged in row arrangements opposite one another in pairs, the rows being aligned parallel to the longitudinal axis of such a measuring head.

It is possible in this case to arrange in one row exclusively optical fibres 3 for exciting light, and in the opposite row exclusively optical fibres 15,

16 for fluorescent light, or at least in one row an alternating arrangement of optical fibres 3 for exciting light and optical fibres 15, 16 for fluorescent light.

Accommodated once again in the measuring head 1 are the light sources 2, preferably exchangeable filters 6 and 8, launching and coupling-out optical systems 25, detectors 4 and the corresponding electronic evaluation and control system 9.

Also represented in Figure 3 are temperature sensors 13 and heating elements 12 which project from the upper socket of the measuring head 1 in the form of a pin or in another suitable form, so that they can be positioned and fixed in a self-closed fashion in connection with correspondingly constructed holding bores in the supports 30 or bodies 40 (still to be described).

The supports 30 or bodies 40 can be mounted on the otherwise planar surface of the socket by means of an optical cement.

A measuring head 1 with a mounted body 40 in accordance with Figure 16 is to be seen in the right-hand representation in Figure 3a.

Figure 3b shows an example of a measuring head 1 on which, again, a support 30 or body 40 can be mounted. The single or a plurality of heating element(s) 12 can be surrounded by a material 12.1 having good thermal conduction.

Represented in two different views in Figure 4 is a first example of a support 30 which, as represented in Figure 3, can be mounted on a measuring head 1, and is made from an optically transparent material.

It is to be noted here that, as also holds for the following pictorial representations 5 to 13, the proportions do not correspond to the actual ones, rather, to simplify and improve comprehension, the width is represented to be substantially larger than is the case in a practical design, and in that for use in

flowing fluid media the width of such a support 30 is substantially smaller in relation to its length, with the result that the flow resistance is kept correspondingly low.

The support 30 in accordance with Figure 4 comprises two limbs 30′, 30′′ which are optically separated from one another at least partially by an interposed, preferably reflecting layer 36.

In this example, layers 32 containing fluorescing materials are applied to both outer sides of the support 30, and the remaining outer surfaces 37 are likewise constructed or coated to be reflective.

~~The exciting light is now irradiated via optical fibres 3 into at least one of the two end faces of the limbs 30′, 30′′ into the transparent support 30, and the fluorescence is excited there in the layers 32 by multiple reflection. A portion of the fluorescent light is irradiated again into the support 30 and, by reflection at the outer surfaces of the support 30, directed onto optical fibres 15, 16 for fluorescent light by the lower end faces of one or both limbs 30′, 30′′, and the intensity of the fluorescent light is detected by detectors 4 and, consequently, the material concentration can be measured as a consequence of fluorescence quenching.~~

Also to be seen in the left-hand representation of Figure 4 is the fact that the upper bounding surfaces of the support 30 are constructed inclined at an angle to one another, the angle being selected such that optimum reflection conditions can be achieved in accordance with the wavelengths used.

Represented in the right-hand representation of Figure 4 is a view orthogonal to the longitudinal axis of such a support 30, from which it may be seen that a plurality of regions can be separated optically from one another (also possible in the following examples) by, for example, reflecting layers 38, and different layers 32.1, 32.2 and 32.3 are applied or constructed in the regions. Given these different layers 32.1 to

32.3, it is possible to use a measuring head 1 according to the invention to determine a plurality of material concentrations simultaneously and/or to carry out at least one reference measurement in one of these regions. The same reference numerals are used for identical elements in the following figures.

A further variant of a support 30 is represented in Figure 5, this variant differing from those previously described only in the outer contour.

The example, represented in Figure 6 likewise in two views, of a support 30 which can be mounted on a measuring head 1 according to the invention corresponds essentially to parts of the support 30 already mentioned in the description of Figure 4.

The only point is that a cavity reaching over the entire length of the support 30, or one or more cutouts, whose surfaces are also provided with a reflecting coating 36 is/are constructed between the limbs 30′ and 30′′.

A self-closing fastening on the measuring head 1 can be achieved with this cavity or the cutout(s).

Constructed for this purpose on the surface of the measuring head 1 is an appropriate longitudinal web which can engage in a self-closed fashion in the cavity constructed in the support 30, and can hold it correspondingly.

If one or more cutouts are constructed in the support 30, the correspondingly shaped and contoured heating elements 12 and temperature sensors 13, or other, for example, pin-shaped elements without a further function, can, constructed exclusively for fastening such a support 30 on the measuring head 1, be inserted into the cutouts or cavities in a self-closed fashion and be held there fastened appropriately.

The support 30 likewise represented in two views in Figure 7 differs from the support 30 shown in Figure 6 once again only in the web-like flattening in the upper region.

In the support 30 represented in Figure 8, the layers 32 containing fluorescing materials are applied in the inclined upper region, with the result that they are not aligned parallel to one another, but are inclined relative to one another.

A particular design has been selected in the example of a support 30 represented in Figure 9. Use is made in this case only of a support 30 to which layer(s) 32.1 to 32.3 containing one or more fluorescing materials are applied, and, at a spacing therefrom, an otherwise symmetrically constructed planar optical conductor 35 which both have, above the layer(s) 32 containing fluorescing materials, a surface which is inclined at an angle and at which both the exciting light and the fluorescent light are reflected. In this example, exciting light is launched exclusively into the lower end face of the support 30 and reflected therein, so that fluorescence is excited in the layer(s) 32. Since the opposite surfaces of the support 30 and of the planar optical conductor 35 are constructed or coated in a reflecting fashion only in the lower part, at least a portion of the fluorescent light can pass by reflection at the inclined surface of the support 30 into the planar optical conductor 35 and be directed from the lower end face thereof via the appropriately arranged optical fibres onto the detectors for the purpose of measuring the fluorescence intensity. However, instead of the reflecting layers 36, it is also possible to introduce a less strongly refracting medium into the interspace in a fashion producing the same effect, this state of affairs also being valid for the examples according to Figures 6 to 8.

Moreover, instead of the planar optical conductor 35, it is also possible to use a second support 30, so that a symmetrical arrangement can be achieved, in which case it is then also possible thereby to apply different layers 32.

In the example represented in Figure 10, by contrast, for example in accordance with Figure 9, the layers 32 containing fluorescing materials are constructed or applied in the upper, inclined region of the supports 30.

In the supports 30 represented in Figure 4 to Figure 15, the layers 32 containing fluorescing materials can be applied directly to the corresponding surfaces of the supports 30. In another variant, however, the layers 32 containing fluorescing materials can be applied in advance to a preferably plate-shaped transparent substrate and be fastened subsequently thereto on the respective support 30 at the respective location, it being possible for this purpose to make use of mechanically acting self-closed and/or force-closed connections alone or in conjunction with an optically suitable binding agent, or of such a binding agent alone.

Figure 11 represents possible variants of the construction of end faces of the supports 30 or of the planar optical conductors 35 into which or from which the exciting light or the fluorescent light can respectively be launched or coupled out, these end faces being correspondingly inclined in all these examples such that the reflection in the limbs 30′, 30′′ of the supports 30 can be optimized, on the one hand, for the excitation of the fluorescence and, on the other hand, for the alignment of the fluorescent light to be measured.

In these cases, the upper part of the measuring head 1, on which such a support 30 is to be mounted, must be of complementary shape in order to avoid optical losses. The same also applies to the supports 30 of the examples according to Figures 14 and 15.

Figures 12 and 13 show further possibilities of how a support 30 can be constructed, only slightly modified U shapes having been represented here by way example.

Figures 14 and 15 show rotationally symmetrical supports 30 whose upper part is of conical construction, and in which the layers 32.1 and 32.2 containing fluorescing materials are arranged or constructed in the shape of a circular ring around the outer lateral surface of the support 30, if appropriate on an additional, appropriately constructed support, or directly on the surface.

The two examples of Figures 14 and 15 differ only in the construction of the reflecting coating 36. In both examples, the light is launched into and coupled out of the support 30 through conically recessed end faces.

Represented in Figure 16 is a body 40 made from an optically scattering material such as, for example, a polyester filled with titanium oxide, aluminium oxide or zirconium oxide, to which, in turn, layers 32.1 and 32.2 containing fluorescing materials are applied directly or on a flat substrate.

Such a body 40, which can also be designated as a diffuser plate, can have cutouts or cavities 42 which are dimensioned and arranged such that the body 40 can be mounted on a measuring head 1 as represented, for example, in Figure 3. In this case, the exciting light is radiated into the body 40 by the optical fibre 3 and distributed there diffusely, as a result of which a uniform excitation of fluorescence is achieved in the layers 32 and at least a portion of the fluorescent light is redirected into the body 40, and directed from there into the optical fibres 16 and 15 onto the detectors 4 for the purpose of measuring the fluorescence intensity.

It is also possible that the fluorescent light can be launched into the optical fibres 15, 16 from an end face of the layer(s) 32, and can thereby be directed onto the detector(s) 4, 5.

Such a body 40 can, however, also consist of an optically transparent material which is provided on the exposed surfaces with a reflecting coating, and the

surface of the body 40 is constructed in an optically scattering fashion in the region of the layers 32 containing fluorescing materials.

A cap 41 with a body 40, which can be constructed, in turn, as already set forth in the description of Figure 16, is shown in Figure 17, and on the body 40, in turn, at least one layer 32 containing a fluorescing material is arranged or constructed there. As was represented, for example, in Figure 1, the cap 41 can then be mounted on a measuring head 1, and in this case the arrangement and alignment of the optical fibres 15 and 16 for the fluorescent light should be performed to correspond with those of the respective layers 32.1 or 32.3.

A further example of a body 40 which can already be constructed, as mentioned above, is represented in Figure 18.

Such a body 40, can, in turn, easily be made available in a simple way as an exchangeable part, as is also the case for the cap 41 in accordance with Figure 17 and the body 40 in accordance with Figure 16.

If, as also represented in Figure 3a, the body 40 according to Figure 18 is mounted on a measuring head 1, the light of the light source 2 passes relatively accurately into the middle of the body 40 and is scattered there diffusely and fluorescence is excited in the layers 32.1 and 32.3 virtually simultaneously. The fluorescent light retroreflected into the body 40 passes via the limbs 40′ and 40′′ of the body 40 and the optical fibres 15 via an optical system 25 onto a photodetector 4, it being possible for an optical filter 8 to be arranged upstream of the latter, and the evaluation of the measuring signals being carried out with the electronic system 9 integrated in the measuring head 1.

Figures 19 and 20 represent two examples of holders 43 on which it is possible to fasten layers 32.1 and 32.2 containing fluorescing materials. These layers 32.1 and 32.2 are preferably applied to a plane,

flat, transparent substrate which can be fastened on the holder 43 in a self-closed fashion and/or with a binding agent.

A holder 43 thus prepared can then readily be mounted and fastened on, for example, a body 40 which can, if appropriate, be a permanent component of a measuring head 1, as is represented in Figure 3a.

Represented in Figure 21 is a further example of a measuring head 1 according to the invention, on whose upper tip there is arranged, in turn, a layer 11 in which at least one fluorescing material is contained. Arranged, in turn, below this layer 11 is a temperature sensor 13 and a heating element 12, the aim being, if required, to prevent the formation of condensate on the layer 11.

The exciting light is once again launched into an optical fibre 3 starting from the light source 2 via an optical system 53 and an exchangeable filter 6, and directed onto the layer 11. The excited fluorescent light passes via the optical fibre 15, the optical systems 52 and the exchangeable filter 8 into a spectrometer 50, for the purpose of wavelength-resolved measurement, to different detectors 54′ and 54′′ via an optocoupler 51.

A further example of a measuring head 1 according to the invention is represented in Figure 22, in two views. In this case, the exciting light of the light source 2 is launched only on one side into a limb 30′ or 30′′ of a support 30 such as is represented in Figures 4 to 15, and coupled out again from the respective other limb 30′ or 30′′ or both limbs 30′ and 30′′, and directed onto detectors 4 in order to determine the fluorescence intensity.